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## Original Articles.

# CONTRIBUTION TO THE STUDY OF SPINAL FRACTURE WITH SPECIAL REFERENCE TO THE QUESTION OF OPERATIVE INTERFERENCE.*

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Twelve years ago Thorburn predicted that surgeons would "probably, in the near future, open the spinal canal with as little danger and as little hesitation as they now operate upon the cavity of the cranium"; adding that in order to permit of such an extension of therapeutic art it would be necessary still further to increase the accuracy of our diagnostic methods. This prediction has been already verified, and to no author more than to Thorburn is due the present accuracy of our diagnostic methods.

Experience has even shown that spinal operation is comparatively free from the drawbacks and dangers attending intracranial surgery. This fact, together with the serious, painful and usually fatal nature of the lesion under consideration, renders the question pertinent whether it is not wise to make early operation the common custom, in the hope, not only of relieving pain, and of improving the course of the average case, but even of saving an occasional patient from helpless invalidism if not from death. This is the main question, the discussion of which this paper is intended to reopen.

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It is especially desirable that the question be discussed whether we really have reliable symptoms establishing (except through their persistence) irremediable crush of the cord; for if we have not, are we doing justice to the patient when we rely on the time-honored dictum that the damage was done at the moment of impact, that the pressure of fragments has been spontaneously relieved, and that nothing can be accomplished by operation? Enough cases have been published, both operative and non-operative, with more or less complete restoration of function after initial symptoms accepted by Kocher and others as indicating complete transverse lesion of the cord, to establish the fact that such lesions are sometimes capable of considerable restoration (Hammond[2], Lloyd[3], Honan[4], Israel[5], Korteweg[6], Pyle[7], and others), and Case III of this paper may be added to the list. It is to be understood at the outset, therefore, that though we may follow the classification of Kocher[8], Bastian[9], Thorburn[10], and others, the terms complete and incomplete lesion should not imply that the symptoms of the former are necessarily incapable of amelioration. This distinction has an important bearing on the question of operation, for Kocher states (p. 479) that operation is out of the question in case of total transverse lesion, though in case of partial lesion we may operate later, when long continued pressure is shown. In discussing the question of operative interference I shall claim no originality in venturing to dissent from these views on the ground (1) that we have no symptoms from which we can assert at the outset that the cord is crushed beyond, at least, a certain degree of repair, and (2) that we cannot predict which cases will fall into his second category, and that early operation in all doubtful cases will not only accomplish all that late operation will do for these cases, but it will be performed to better advantage before reparative processes with adhesion and callus have appeared.

I shall first review the symptomatology, illustrating by personal observations, then discuss the prognosis and the question of operation, then consider briefly such points in the technique as seem appropriate.

### SYMPTOMATOLOGY.

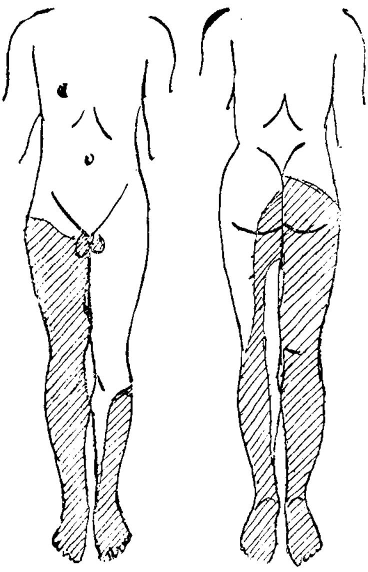
*Motion.*—Fracture of the spine with complete transverse lesion of the cord is accompanied by immediate relaxed motor paralysis involving the parts below the level of the lesion. There is entire absence of rigidity, of spasm, convulsive movement or other irritative sign in the motor sphere. The statement that signs of *motor* irritation may appear at the level of the lesion seems based rather upon theoretical considerations than upon actual observation.

Partial injury to the cord, including the results of hemorrhage, may be indicated by a slower onset of paralysis, by a unilateral or irregular distribution (affecting, for example, the arms more than the legs), by the preservation, or comparative preservation of reflexes and by the rapid improvement.

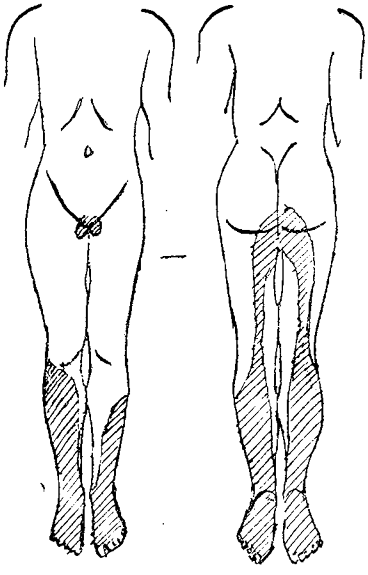
In diagnosticating the level of the lesion by studying the muscles involved in the paralysis, the tables of Thorburn, based on clinical rather than on anatomical or experimental considerations, have stood the test of .practical application. It would appear that the motor symptoms may reach a much higher level than the sensory, at least in case of lesion of the lumbar enlargement. This may be illustrated by the following example, in which the area of anesthesia after operation reached no higher on either side than the sacral distribution, whereas the motor paralysis included the muscles supplied by the lumbar segments.

Case I.—A man of middle age fell from a second story window striking on the middle of the back. Paralysis followed. He was taken immediately to the Massachusetts General Hospital, entering the service of Dr. Conant, who kindly allows me to report the case. He was seen also by Drs. Baldwin and Paul who concurred in advising operation.

There was complete relaxed motor paralysis of the lower limbs. There was total anesthesia up to the groin on the right; on the left the anesthesia was limited to the outer aspect of the front of the leg below the knee, to the back of the leg and to a strip on the back of the thigh, the saddle-shaped area, the perineum, the scrotum and penis. (See Figs. I and II.) The reflexes were entirely wanting, including the knee-jerk, plantar, cremaster, abdominal and epigastric. Retention of urine was present. There was excoriation over the first lumbar spine with infiltration of the tissues. The first lumbar spine was depressed, and pressure in that region was extremely painful. Rolling the patient over caused excruciating pain at this point. The patient was markedly alcoholic and delirium tremens was anticipated without as well as with operation; it was therefore decided to operate.



Figs. I and II



Figs. III and IV

Figs. I and II. Areas of total anesthesia in Case 1, before Operation.
Fig. III and IV. Anesthetic area in Case 1 after operation, showing disappearance, on the right, of that part of the anesthesia due to pressure on nerve roots.

Operation, performed by Dr. Balch, revealed fracture of the first lumbar vertebra involving only the lamina on the left, but on the right extending into the transverse process. The separated portion was removed, together with fragments of the twelfth dorsal which were found inpinging upon the cord. The dura was freely opened, showing no discoloration or change in the consistency of the cord. There was free flow of cerebro-spinal fluid. The dura was not sutured, and the wound was closed without drainage. The wound healed practically by first intention. Moderate pain in the back persisted during the day following operation, but had become less two days after operation, from which time the patient expressed himself as comfortable and allowed himself to be rolled over without complaint. On the seventh day the expected delirium tremens appeared and lasted three days. The anesthetic area in the right leg was reduced within a few days to the sacral distribution.

The lower extremities remained warm and dry till the seventh day, when the left foot became cold and remained so for two days, after which it was less cold but still far below the temperature of the other foot. The skin temperatures on the fourteenth day after operation were as follows: Dorsum of right foot 93°; dorsum of left foot 88 1-2°; front of right thigh 94°; front of left thigh 91 1-2°.

The temperatures of the dorsum of the hand and front of the forearms taken for comparison were as follows: Dorsum of left hand 85°; front of forearms, left 93 3-4°; right 92 3-4°.

The temperature taken in the mouth at this time was 98°. At this date no material change had occurred in motion, sensation, reflexes or bladder and rectum control, though he could now feel the presure of the urine or the flatus, over which he had no voluntary control. This patient can now (two months later) move the left thigh, and is very comfortable. Paralysis and reflexes are otherwise unchanged; there is no bed-sore.

This case will also be cited to illustrate the fact that unequal anesthesia does not preclude fracture, and will be referred to under the question of vaso-motor disturbance.

Dr. Warren[11], with the concurrent advice of Drs. Putnam, Baldwin, Taylor and myself, nineteen days after injury, removed, in 1896, the laminæ of the twelfth dorsal and first and second lumbar vertebræ in a case of spinal fracture presenting very similar symptoms, and exhibited the patient at a recent medical meeting. At that time he had slight toe-drop on the left and walked with slight assistance from crutch and cane. The bladder was still improving, and he had not used the catheter for a year.

*Sensation.*—In fracture with total transverse lesion the area of anesthesia is generally sharply marked, and at a level corresponding to the segment crushed, that is, at a level materially below the seat of lesion. There is no more fascinating clinical study than that of sensory areas as presented in detail by Starr[12], Thorburn[13], Knapp[14], Kocher, Seiffer[15], and others, but for the purpose of the present résumé it must suffice to remind ourselves in a general way that most authorities agree that the upper roots of the brachial plexus supply the cap of the shoulder and the radial side of the arm and hand, while the lower roots supply a strip down the ulnar side of the arm and hand. The seventh dorsal segment supplies the ensiform region, the eleventh dorsal the umbilicus, and the lumbar the front and outer and inner aspects of the thigh to the groin and the inner aspect of the leg. The sacral supplies the region below the knee in front on the outer aspect, as well as the whole or greater part of the foot; it supplies

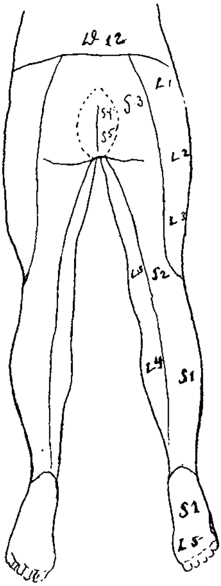
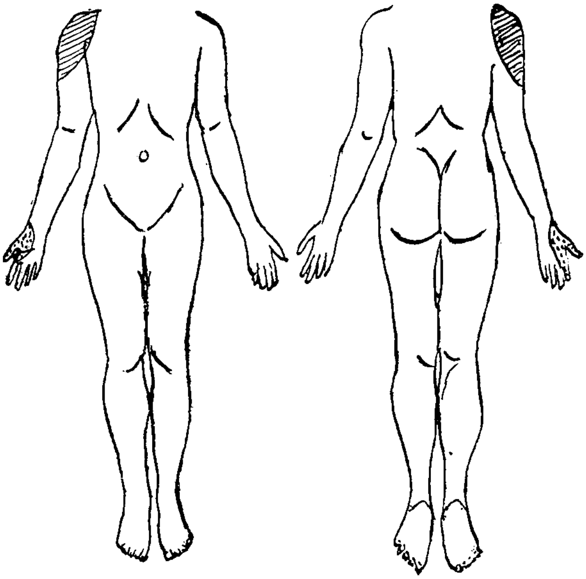


Fig. V. After Seiffer, shows that 12th dorsal and 3d sacral areas are adjacent, the areas supplied by intervening segments having extended down the limb.

also the back of the leg, and a strip in the middle of the posterior surface of the thigh, and the saddle-shaped area, the perineum, scrotum and penis.

The fourth cervical segment furnishes sensation down to a line below the clavicle adjoining the distribution of the second dorsal. The absence of representation on the trunk, of the intervening segments, is explained by the fact that in the budding and growth of the upper extremity the areas supplied by the 5th, 6th, 7th and 8th cervical and the first dorsal are carried down the arm. This is well illustrated by Seiffer's modification of Bolk's diagrams.



Figs. VI and VII. Area of anesthesia limited to supply of 5th cervical root, though 4th, 5th and 6th cervicals were severed.

For a similar reason the 12th dorsal closely approximates the 3d sacral on the buttock.

It is probable that *complete* anesthesia in any area implies loss of the segments above and below the one which supplies that area, as each part of the body receives sensory fibers from these segments. (Sherrington.) This is the probable explanation of the fact that in the following case, seen in consultation with Dr. Mixter at the Massachusetts General Hospital, the only area of complete anesthesia was that of the 5th cervical, the middle of the three severed roots.

Case II.—A man fell upon a sharp object which produced a deep cut on the right side of the neck. Immediate paralysis followed, involving the spinati, the deltoid, biceps, supinator longus, latissimus dorsi and pectoralis major on the right. There was complete anesthesia over the cap of the shoulder in the distribution of the 5th cervical root. The picture was complicated by a paresthetic area in the radial distribution on the hand, perhaps due to injury of the musculo-spiral nerve.

Dr. Mixter found the 4th, 5th and 6th roots severed, and sutured them. Sufficient time has not elapsed to determine the final result.

It should not be forgotten that in case the roots are crushed at the same level as the cord the anesthesia will reach to the level of the lesion. In Case I of this paper, distribution of anesthesia showed that the roots were crushed on one side but spared on the other.

Below the well-known strip of hyperesthesia, which surmounts the anesthesia and points to root irritation, is apt to appear a strip of thermal anesthesia and of analgesia. (Kocher.) That this dissociation is not necessarily limited to the level of the lesion is shown by the following case, of which I am permitted to make a preliminary report. This patient was under the immediate care of Drs. Hinsdale and Washburn with Drs. Cabot and Mixter as surgical consultants. The operation was performed by Dr. Cabot.

Case III.—A young lady was thrown violently upward by an explosion, falling upon her back on the beams of the floor from which the boards had been torn away. Various heavy objects fell upon her. Besides fractures of all four extremities, of the left clavicle, of the nose, and of the sternum, there was complete relaxed paralysis of the lower extremities with loss of all reflexes, (knee-jerk, plantar, abdominal, epigastric.) There was an area of anesthesia bounded by a line just below the mammæ, surmounted by an area of hyperesthesia.

There was complete loss of control and of sensation in the bladder and rectum. There was extreme pain on passive motion and great sensitiveness over the third dorsal, with soreness over the first and second dorsal spines. Dr. Cabot removed the arches of the three upper dorsal vertebræ which were found depressed and impacted. Improvement in general condition was steady, except during a day or two, within a week of the operation, when there were signs of collapse with twitching of facial and brachial muscles, and the face and neck were bathed in cold perspiration. The free flow of cerebro-spinal fluid probably had a bearing upon these symptoms which were, however, temporary.

At the end of six weeks the sensation had so far improved that every touch was felt on both lower extremities, and the muscle sense had become normal in the left toes, but thermal sense was absolutely wanting on the left as well as on the right foot.

A large sacral bedsore was healing well. The bladder had been once evacuated voluntarily. The knee-jerk had returned, and become exaggerated with patellar clonus. Moderate Babinski reflex was present on the left; ankle-clonus had not appeared. The patient's general condition was excellent. No definite return of voluntary movement had appeared.

At the end of eight weeks ankle-clonus and Babinski reflex were well established. Nine weeks after operation the patient could flex the left thigh voluntarily, and two days later she could also separate the knees, and extend and flex the toes on the left fairly well, and could do so slightly on the right.

The superficial temperatures at this time were: Dorsum of right foot 94.6, left foot 95; front of right thigh 92.5, left thigh 92.5; dorsum of right hand 90.8, left hand 91.2; upper arm, right 91.5, left arm 91.2; right side of neck 94; right cheek 93.2, left cheek 92.5. The temperature taken by the mouth at this time was 98.4.

Since that time I have not seen her as she returned to Philadelphia, but I am informed she is still improving, though not able to sit up.

Whatever may be the final outcome of this case it certainly may be added to those showing that the classical symptoms of complete transverse lesion do not necessarily indicate a condition beyond repair. It also illustrates the fact that dissociation is not always limited to the height of the lesion. This symptom may point to the fact that the force of the crush is expended with more violence on the gray than on the white matter, thus producing a condition analogous to syringomyelia. The pathological evidence offered, for example, by Thomas[17] is instructive in this connection. It will be remembered, however, that at the last meeting of the American Neurological Association, Thomas[18] presented a case of tumor outside of, and pressing on, the cord in the upper dorsal region, in which case dissociation was present on the whole body below the lesion; he also quoted Strümpell as observing a similar condition. Dr. Baldwin found a similar dissociation in the anesthesic areas of a case of fracture after successful operation by Dr. Mixter. It has been suggested that possibly this symptom may arise from root inquiry.

Incomplete anesthesia points to incomplete lesion of the cord. The same is generally but not invariably true of anesthesia of limited or of unilateral distribution. It is generally true of anesthesia limited to regions far below the level of the lesion and in general the varying modification of the different forms of anesthesia at different levels points to incomplete lesion.

Injury to nerve roots alone sometimes appears in the cervical region after stretching and bruising, perhaps with temporary displacement of vertebræ and rupture of ligaments (distortion). In this lesion the sensory symptoms, like the motor, are apt to be limited to the arms. Courtney[19] has discussed this subject in detail and given cases. This condition is illustrated by the following case.

Case V.—A gentleman twenty-nine years of age, ran down the beach and dove too perpendicularly, striking the top of the head. He was not unconscious. When he first realized where he was he tried to put up his arms and found he could not, then tried to move his legs, also unsuccessfully. He was cold. The head was stiffly bent forward. The use of the legs and right arm returned one-half hour after the accident, but it was four or five days before he could use the left arm at all. When I saw him three months later there was moderate tenderness over the cervical region and a distinct swelling over the transverse processes of both sides. There was no paralysis of motion or sensation and no disturbance of reflexes.

The following case seen with Dr. Jackson represents a less degree of the same lesion.

Case VI.—An athletic gentleman of thirty-one, riding in a hurdle race, was thrown violently over the head of his horse. He turned a somersault and struck on the back of the neck, bending the head violently forward. He picked himself up and walked away though in a dazed condition. There was no numbness and no loss of power. Besides the general lameness and soreness there were pains in the arms and stiffness in the neck. This pain rapidly grew worse on the third day. When I saw him, nine days later, the pain had lessened, but it could be started at any time by slight stroking of the ulnar side of the arm though deep pressure in that region showed no sensitiveness. A tingling and prickling sensation on the ulnar side of both arms was constant. The neck was still somewhat stiff.

The diagnosis "local concussion of the spine" though much less frequently made of late than in former times has still been applied to such cases by certain authors, for example by McCosh[20].

*Vesical, Rectal and Vaso-Motor Symptoms.*—Retention rather than incontinence of urine is the rule in all varieties of spinal fracture with injury to the cord, even when the lesion involves the lumbar region. This probably shows that, even when the sphincter is relaxed, the mechanical conditions are such that the urine does not escape when expulsive force is lacking, so long as the bladder is not over-distended.

There may be either retention or incontinence of feces, more often the former, even though the sphincter be relaxed. The sensation in the rectum and bladder may be preserved in incomplete lesion even though voluntary evacuation is impossible, so that the patient may feel the pressure of flatus or urine over which he has no voluntary control.

The symptoms referable to vaso-motor disturbance are varied and baffling. The most common observation is a rise in the superficial temperature of the lower extremities allied to that observed in hemiplegia from cerebral hemorrhage. This condition is apt to be replaced later by coolness of the extremities and sometimes though not usually, by marked coldness. The skin is generally dry. The rise of local temperature may perhaps be explained by the dilatation of superficial blood vessels due to cutting off the vaso-constrictor influence of the bulbar centers. The subsequent fall may be explained by the gradual resumption of function by vaso-motor centers previously rudimentary in the cord itself. Such, at least, is the explanation given by Porter[21], for the corresponding symptoms appearing in the frog after cutting the spinal cord.

The absence of sweating tends to fortify the theory that the principal sweat center lies in the medulla, the fibers being interrupted in their spinal course by the lesion. The absence of sweat combined with congestion of the skin offers additional proof (not needed) that sweat secretion is dependant on specific nerve fibers, not primarily on heat.

The profuse sweating of neck and face in Case III was probably due to irritation of the sweat fibers in the upper dorsal region. It has been demonstrated in the cat that the sweat fibers to the upper extremity leave the cord in the fourth to the tenth thoracic nerves, pass into the sympathetic chain, then upward to the first thoracic ganglion, passing out of the ganglion by the gray rami communicating with the nerves forming the brachial plexus (Langley[22]).

*Reflexes.*—The fact is now generally recognized that the knee-jerk is lost in case of complete destruction of the cord though the pathology of this condition is still under discussion. Cases of spinal fracture offer no exception to the rule.

The superficial reflexes are also generally lost or diminished in these cases, probably always lost in complete lesion. That this loss is not necessarily limited to the reflexes below the lesion as shown by Case I of this paper, in which case the epigastric and abdominal reflexes were lost, as well as the cremasteric and plantar, though the lesion was at the twelfth dorsal and first lumbar.

The Babinski reflex is a common phenomenon in the course of these cases and may appear when no other reflex is present.

*Local Signs.*—These are generally most unsatisfactory. Either no irregularity is to be detected or an irregularity of doubtful import. Sometimes, however, a distinct knuckle is present and again a distinct depression of the spinous process or a sudden deviation from the vertical line. When such definite signs are present their aid is invaluable, especially if accompanied by infiltration of the over-lying tissues, together with great tendernes on pressure, and by local pain, becoming extreme when the patient is rolled. Fractured sternum always suggests fracture of spine.

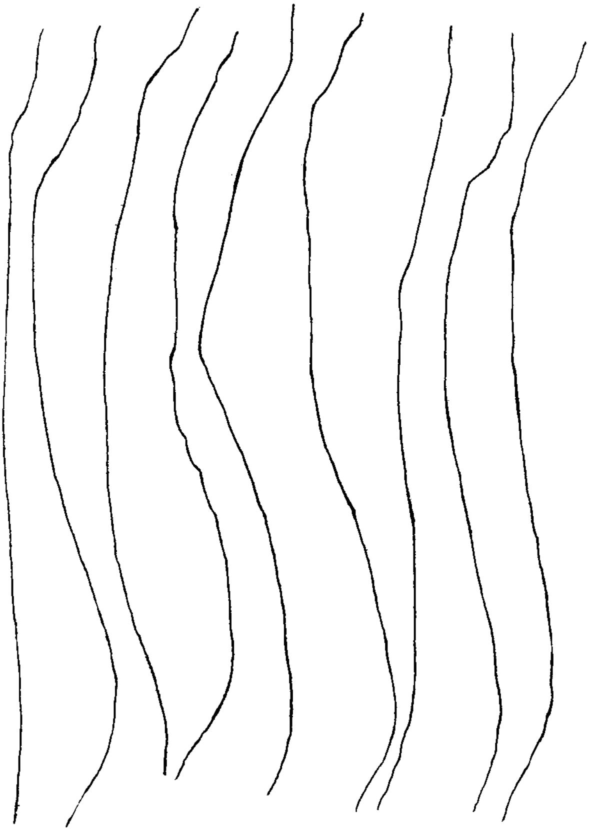


Fig. VIII. Showing variations in dorsal curves in healthy students of gymnastics. All taken facing to the right.

It would seem hardly necessary to mention the physiological irregularities familiar to those who frequently observe the back, and yet it is probable that such irregularities have been mistaken for signs of serious injury by experts as well as by practitioners who have not had occasion or interest to study this portion of the body. I take this opportunity to show the tracings taken from diagrams representing the routine examination of healthy students at the Boston Normal School for Gymnastics. I am under obligation to the Director, Miss Amy Homans, for the opportunity to copy them. It should also be stated that these curves were taken from newcomers, unmodified by training of the school.

The prominence of vertebra in this picture bears a suggestive resemblance to that of Fig. I in the Presidential Address[23] delivered this year before the American Orthopedic Association. The diagnosis made in that case was fracture, or dislocation, of the vertebra, or both, resulting from a fall, though the patient had full control over rectum and bladder, could move the limbs and complained of pain only in the back, sides and abdomen.

He remained in bed several weeks. After he had been up a few days the prominence was observed of one or two vertebræ in the (lower) dorsal region. This was found to increase.

Another picture represents a still more common irregularity. It may be taken as the subject bends slightly forward and the prominence of vertebral spines in the lower dorsal and upper lumbar region is apparent as a normal photograph will show very readily. For anatomical reasons, flexion in the spinal colum is freer in this region than in the upper dorsal. If sprain of the back is present this position is habitually maintained, so that the prominence may be easily mistaken for a permanent one.

The Roentgen rays may be of value in diagnosis. Lathrop[24] states that the nature of a fracture can be easily made out by this aid. Kienbock[25] states that this procedure is important in showing the variety of fracture and whether the cord or roots are compressed, but adds that it is often undesirable on account of moving the patient about. In the cases which have come under my observation this method has not rendered material aid, though it must of course be of service in case of great displacement.

## PROGNOSIS.

The prognosis in cervical cases without operation is generally grave. In Kocher's twelve cases the average duration of life was one week. In Courtney's collection of City Hospital cases the average death occurred within five days. In Baldwin's collection of Massachusetts General Hospital cases since 1870 (36) the average death occurred in five days, all being fatal.

The prognosis in fracture of the dorsal and lumbar region without operation is better than that of the cervical region but is still grave. Lloyd[26] quotes Burrell's statistics of Boston City Hospital cases including all localities and showing a fatality of 79% in 82 cases, and those of Gault, 80% in 270 cases. In contrast to these figures he has found a fatality of slightly below 50% in his exhaustive collection of reported operative cases. Keen quotes Chipault's statistics also, (40%) and Thorburn's (57%), and Horsley has laid great stress upon them in favoring operation. These statistics, though impressive are not infallible, since they are open to the objection that many unsuccessful cases are unpublished.

But even if final statistics made under conditions free from this objection, should reveal a percentage of fatality materially higher, the question would still remain whether the lessening of discomfort and disability is not enough to warrant operation. The difference between the bed and the invalid chair, between the healthy and the disordered bladder, and like considerations, should go far to turn the balance in favor of operation. While on the question of statistics, it may be pertinent to suggest that the collaboration of such reports as that of McCosh, while open to other dangers, would be free from the objection I have indicated. McCosh reports a personal experience of six cases of which four were fatal.

In pursuance of this plan Dr. Baldwin has kindly collected for me the cases operated on at the Massachusetts General Hospital since 1870. The operations number fifteen; there were ten deaths, showing a fatality of 66 2-3%. Dr. Munro has kindly sent me an analysis of thirteen personal cases, with fatality of ten. We have here, therefore, a record of 34 cases not open to the objection of non-reported cases, and showing a fatality of twenty-four, that is, slightly over 70%.

### THE QUESTION OF EARLY OPERATION.

The advisability of laminectomy for spinal fractures has offered a fairly fertile field for discussion since the famous verbal duel of Sir Charles Bell and Sir Astley Cooper.

We may perhaps fairly include among those on this side of the water who, with Thorburn and Kocher, regard the operation as justified under certain conditions, Keen[27], Lathrop[28], Deaver[29], Scudder[30], Roberts[31] and McCosh [32]. Among those whose reports and whose remarks indicate a tendency to free recourse to early operation may be mentioned Hammond[33], Phelps[34], Burrell[35], Munro[36], Weeks[37], Means[38], Honan[39] and Abbe[40]. This division is perhaps too arbitrary, and personal communication shows a general tendency to abandon the conservative view. That the operation is in some quarters questioned and even denounced is shown by an editorial in the Medical News of 1900[41], as well as by the address of Gillette already referred to. The scathing remarks of Leyden[42] were made before the introduction of modern surgical methods.

Of the four divisions under which Thorburn discussed the question in 1899 we may now eliminate two, namely (1) whether the operation is necessarily fatal, or so dangerous as to be unjustifiable, and (2) if successful is it likely to leave the vertebral column too weak to perform its functions. Apprehension regarding the danger of the operation has now been completely allayed. The question as to the weakening of the spinal column has been answered in the negative by the report of many cases. We are left only with Thorburn's second and third questions, namely, (2) how far are the spinal injuries curable without operation? and (3) what is the prospect of improvement by operation? Statistics gathered since 1889 have shown that modern methods of treatment other than operation have done little towards improving the prognosis. Burrell, who originally advocated extension and fixation, argued strongly already in 1893 for early operative interference, the discussion taking place at a meeting of the British Medical Association, at which Thorburn took a more conservative view. Dr. Burrell assures me in a personal communication that he is still in favor of early operative interference, except in those cases of extensive fracture of vertebral bodies in which the Roentgen rays demonstrate extreme displacement. In such cases he deems it wiser to resort to immediate rectification and fixation. This exception is most reasonable; its validity was illustrated by the following case upon which Dr. Warren recently operated by my advice. He kindly allows me to put it on record.

Case VIII.—A man of forty-eight years fell in the hold of a vessel and was struck by a heavy bale, and was taken to the Massachusetts General Hospital, entering the service of Dr. Warren. Relaxed paralysis of lower extremities followed with loss of all reflexes, and with anesthesia to the groin. There was retention of urine. Marked kyphosis appeared in the dorso-lumbar region. No crepitus could be felt, but there was apparent displacement of the 12th dorsal and first lumbar vertebræ. Fracture of ribs and of the left femur complicated the case, and the patient's general condition was poor.

Operation (on the fourth day) showed great displacement. The cord was exposed with difficulty and was found much bruised. The dura was split and there were signs of considerable extra-dural hemorrhage. The wound was closed without drainage. The patient's condition grew rapidly worse and he died the day following operation.

This case was obviously hopeless whether operation, rectification and fixation, or the expectant plan were followed, but the remote chance of benefit from operation would perhaps bring it under Burrell's rule.

Is the prognosis of spinal fracture in general better with operation? It is doubtless true that in *most* cases a crush of the cord has taken place and that the pressure of fragments has been spontaneously removed. But even if the conclusion of Thorburn is correct that in *most* of these cases no benefit can accrue from operation, his deduction therefrom that operation is *unjustifiable* does not necessarily follow. To his statement that operation should be abandoned he made two important exceptions, namely, (1) injuries to the cauda equina, and (2) cases in which the lesion is limited to the arches.

However sound these principles may be in theory would the best of diagnosticians claim that it is always possible to state with certainty whether the cord has been crushed, and whether the bony lesion is limited to the arches or not, and is there no danger that in pausing too long over this diagnosis we may sometimes fail to do our patient justice?

Kocher regards operation as out of the question in case symptoms of complete crush have appeared, but we have seen that these symptoms are not to be absolutely relied upon. How, then, are we to decide if not by these symptoms whether we have to do with a cord crushed beyond repair or with one capable of a certain degree of restoration? Kocher favors operation in cases of incomplete lesion when the symptoms have come to a standstill, but if we cannot always diagnosticate the incomplete lesion, nor deny in a given case that the symptoms may improve and finally come to a standstill, is it not wise to operate in cases in which a shadow of a doubt is felt?

In short, whether we have to do with complete luxation fracture or with partial injury, as fracture of the arch alone, whether the transverse process or the vertebral body is invaded, whether the fractured spine is so far displaced that the cord is hopelessly crushed against the body of the vertebra, whether in case of depressed arch the fragments are still pressing on the cord, whether hemorrhage has taken place inside or outside the dura, whether the nerve roots are crushed or irritated only, upon all these questions we may speculate, and upon some draw fairly accurate conclusions, but operation will often disclose a state of affairs quite at variance with our diagnosis.

Should not such conclusions lead us to give the benefit of the doubt to an operation which has proved at the worst neither materially dangerous to life nor detrimental to comfort, and which at least may be expected to lessen pain, to reveal the nature of the lesion with which we are dealing, and to place the cord in the best position for restoration of its function when such restoration is possible, and if we may add to these comparatively modest claims the hope than an occasional life may be saved, and an occasional patient rescued from helpless invalidism of the most distressing character, should not the burden of proof be laid upon conservatism?

Whether the improvement sometimes seen in operative cases would have taken place without operation is a matter of speculation, nor are we perhaps yet in position to make a final comparison between the results of operative and non-operative treatment. The failure to report unfavorable cases arises not from any attempt at concealment of unfruitful operation but rather from lack of incentive to present a paper with no more attractive title than: "Case of Spinal Fracture; Operation; Death." The only fair criterion for comparison would be an experience accumulated during many years in which free, early operation has been practised. It is in the hope of adding incentive to the accumulation of such experience that this contribution is offered.

What we need now is more facts; those coming later will be best able to estimate their value. With regard to my personal experience I can only say that the course of such operative cases as have come under my observation has been on the whole more favorable than my previous experience and study of the literature would have led me to expect without operation.

## OPERATIVE DETAILS.

Without attempting to encroach upon the province of the surgeon it may still be in place to allude to one or two details upon which the neurologist is apt to be consulted.

It is generally wise to open the dura freely; it is apt to be found bulging and tense, and the free escape of the cerebrospinal fluid does no harm, and may do good by relieving pressure and thus remove a possible bar to the repair of the cord. An edematous condition of the arachnoid is apt to appear, a condition which free drainage may do something to relieve. The additional advantage of opening the dura consists in the free view afforded of the cord itself. I am informed that a remarkable case has been unofficially reported which still further emphasizes the importance of viewing the cord itself. In this case the cord was found severed and was immediately sutured. At the time of the report a certain degree of improvement had set in. The future history of this case will be awaited with great interest.

The next question the neurologist is asked is regarding the advisability of suturing the dura. Kocher states that this should be done to prevent serious symptoms from lessened pressure due to loss of cerebro-spinal fluid, but of late the custom of leaving the incision freely open has grown in favor and in no case, I believe, has untoward result followed. In Case III of this paper the twitching of face and arms was attributed to loss of the fluid, but the symptoms were only temporary. In no other case have I seen note of symptoms attributable to this cause.

The next question is that of drainage. It has been the usual custom till recently to secure a certain amount of drainage for at least a day or two. That this is unnecessary, however, is shown by the experience of various writers and was illustrated by Case I of this paper. This plan, if only equally successful with the plan of inserting drainage, offers the additional advantage of quick healing, agreeable dressing and freedom from danger of sepsis.

The question of operating immediately or waiting for the shock to subside is one falling rather under the province of the surgeon. Munro favors waiting if the shock is great, whereas Bouffleur[42] does not regard shock as contra-indicating immediate operation, arguing that the operation is directed toward the relief of the very cause of the shock. If a patient operated on during the shock produced by this grave injury should succumb during or immediately after operation, it would certainly indicate that the original lesion was of so serious a nature that recovery would be out of the question in any case, and immediate operation, though futile, would hardly be open to serious criticism. Still, in case of grave shock it would seem reasonable to delay, especially as some time is needed to ascertain the extent of the symptoms, whether, for example, they may not be the temporary result of distortion. Early operation does not necessarily mean immediate operation. A delay of hours is not important, but that of days may be, since degenerative processes set in early, according to Lloyd on the fourth day.

## CONCLUSIONS.

(1) There are no symptoms which establish (otherwise than through their persistence) irremediable crush of the cord.

(2) While total relaxed paralysis, anesthesia of abrupt demarkation, total loss of reflexes, retention, priapism and tympanitis, if persistent, point to complete and incurable transverse lesion, the onset of such symptoms does not preclude a certain degree at least of restoration of function.

(3) The prognosis without operation is grave.

(4) While the results of operation are not brilliant, they are sufficiently encouraging to warrant us in making the practice more general.

(5) In most cases it will be wise to operate within a few days of the injury, but a delay of some hours is advisable, partly on account of shock and partly to eliminate the diagnosis of simple distortion.

(6) We have no infallible guide to the extent of the lesion. The operation at the worst does not materially endanger life nor affect unfavorably the course of the case, and may at least reveal the lesion and lessen the pain; it may sometimes save a patient from death or from helpless invalidism of most distressing character. Instead of selecting the occasional case for operation, we should rather select the occasional case in which it is contra-indicated (the patient with great displacement of vertebræ, the patient with high and rising temperature, the patient plainly moribund, the patient still under profound shock.)

(7) The dura should be opened freely; it need not be sutured; drainage is not necessary.

## REFERENCES.

[1] Thorburn, "Contribution to the Surgery of the Spinal Cord," Lon. 1889.

[2] Hammond, Jour. Nerv. & Ment. Dis., 1893, p. 477.

[3] Lloyd, Jour. Am. Med. Assn., April 20, 1901, p. 1116.

[4] Honan, Med. Times, N. Y., 1900, xxviii, p. 217, 218.

[5] Israel, Cited by Chipault, "Chirurgie Operatoire du Systeme Nerveux," 1895, 11, p. 99.

[6] Korteweg, *Idem.* page. 101.

[7] Pyle, Annals of Surgery, 1894, xix, p. 664.

[8] Kocher, "Verletzungen der Wirbelsaule," u.s.w. xxv, p. 553, et seg.

[9] Bastian, Med. Chir. Trans., 1890, lxxiii, p. 151.

[10] Thorburn, Manchester Med. Chron., 1892, xvi, p. 73.

[11] Warren, Boston M. and S. Jour., May, 1899.

[12] Starr, Am. Jour. Med. Sci. vol. civ, 1892, pp. 15-35.

[13] Thorburn, *loc. cit.* also Brain, vols. ix, x, xi, and xvi, and Brit. Med. Jour., vol. ii, 1888.

[14] Knapp, Jour. Nerv. and Ment. Dis., Sept., 1897.

[15] Seiffer, Arch. f. Psychiatrie u. Nervenkrankheiten, 1901, B. 34, H. 2, p. 648.

[16] Bolk, Morphol. Jahrb. 1898 (25 & 26), 1899 (27), 1900 (27).

[17] Thomas, Boston City Hospital Reports, 11th Series, 1900.

[18] Thomas, Boston Med. & Surg. Jour., Oct. 3, 1901.

[19] Courtney, Boston Med. & Surg. Jour., April 5, 1900.

[20] McCosh, Jour. Am. Med. Assn., Aug. 31-Sept. 7, 1901.

[21] Porter, "Am. Text Book of Physiology," p. 490.

[22] Langeley, Jour. of Physiology, 1898, Vol. xii, p. 347.

[23] Gillette, St. Paul Med. Jour., July, 1901.

[24] Lathrop, Am. Surg., Phil. 1900, xxxii, pp. 833-842.

[25] Kienbock, Wien. klin. Wochenshr., 1901, Vol. xiv, pp. 405-409.

[26] Lloyd, *loc. cit.*

[27] Keen, "Dennis Surgery."

[28] Lathrop, *loc. cit.*

[29] Deaver, Personal communication cited by Lathrop *loc. cit.*

[30] Scudder, "Treatise on Fractures," 2d Edition, 1901, p. 84.

[31] Roberts, "Modern Surgery."

[32] McCosh, *loc. cit.*

[33] Hammond. *loc. cit.*

[34] Phelps, Jour. Nerv. and Ment. Dis., 1893, p. 407.

[35] Burrell, Brit. Med. Jour., 1894, 2, pp. 910, 911.

[36] Munro, Jour. Am. Med. Ass'n., Jan. 6, 1900.

[37] Weeks, Am. Medicine, May, 1901.

[38] Means, Discussion of McCosh's paper, *loc. cit.*

[39] Honan, Med. Times, N. Y., 1900, xxviii, pp. 217, 218.

[40] Abbe, Med. Rec., N. Y., Mar. 3, 1900, p. 353.

[41] N. Y. Med. News, 1900, p. 385.

[42] Leyden, "Klinik der Rückenmarkskrankheiten.

[43] Bouffleur, Discussion Munro's paper, *loc. cit.*